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ON THE OSTEOLOGY OF SOME OF THE LORICATI

WITH FIVE PLATES

BY

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Henry B. Ward, No. 56

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INTRODUCTION

The suborder Loricati is characterized by the extension of the third suborbital bone across the cheek to the preopercle. This group has a wide range of variation and Gill has divided it into several families of which the rock fishes, or Scorpaenidae, are more generalized and the sculpins, or Cottidae, are the most specialized. The family Hexagrammidae comes between the two extremes, being more nearly related to the Scorpaenidae than to the Cottidae.

The purpose of this paper is to make a comparative study of the osteology of these forms in order to determine their relationship. Allen (1905) states that there are many points of resemblance to the Cottidae to be found in their osteology, visceral organs, and vascular systems, and that *Ophidon* is about as closely related to *Scorpionichthys,* a sculpin, as it is to *Hexagrammos,* and should be regarded as a type of a distinct family. For this study *Ophidon elongatus* and *Hexagrammos decagrammus* of the Hexagrammidae and *Scorpionichthys marmoratus* of the Cottidae were selected. The material was collected at Monterey Bay, California, by Mr. William F. Allen under whose direction the work was carried on at the Zoological Laboratory of the University of Illinois.

OPHIDON ELONGATUS

The Cranium

Except for a few ridges and grooves, the entire dorsal surface of the skull (Fig. 1) is flattened. On the anterior half there is a median rectangular groove which extends from between the posterior boundaries of the orbits to the median ridge of the ethmoid. Posterior to the groove the parietals form a ridge on either side, extending laterally and posteriorly, from the median line to the lateral edges of the epiotics. These ridges are continuations of the long rounded ridges of the frontals which form the sides of the rectangular grooves. The surface of the frontals, posterior to the orbits, is somewhat porous and has striations which pass caudad and mesad from the edge of the orbits toward the parietals

The temporal fossa is formed by the pteroties, frontals, parietals and epiotics. It extends caudad from the latero-posterior edge of the

frontal to the caudad end of the skull. In the anterior half it is comparatively shallow, but throughout the posterior half it has a depth of nearly one-third that of the skull. The fossa harbors some of the muscles of the shoulder girdle. The dilatator fossae (Fig. 5-6) are pits on the dorso-lateral edges of the skull, directly above the two articular facets of the hyomandibular. Anteriorly, each pit lies in the sphenotic and posteriorly in the pterotic. The pterotic forms the greater part of the roof of the pit while the most dorsal edge of the proötic forms a part of the ventral edge. Two foramina are present in the pit for the branches of the oticus vessels. The arch of the proötic which forms the bridge over the foramina for the fifth and seventh nerves, the juglar vein and the external carotids is conspicuous in *Ophidon*. It begins at the anterior central portion of the bone and extends dorsad to the ventral edge of the anterior articular facet of the hyomandibular on the sphenotic.

Vomer.—The vomer (Fig. 1) is the anterior bone of the skull and caps the cartilage from the ends of the ethmoid and the prefrontals. It possesses both dorsal and ventral processes. The dorsal and anterior one passes upward and posteriorly and articulates with the ethmoid and prefrontals. The ventral process forms a part of the ventral surface; it passes posteriorly and gradually tapers to a point in the parasphenoid. A V-shaped slit is present in the dorsal process and forms a trough-like cavity with the ventral process, allowing the cartilaginous portion of the ethmoid to pass into it. The anterior edge is broad V-shaped in the median line and rounded from the median portion laterad forming a large expansion at each side. Two kinds of teeth are present on the vomer; an inner row of large canine-shaped ones and an outer row of the villiform variety in which the teeth are irregularly arranged. Both kinds are slightly curved caudad and are placed in sockets. The maxilla and premaxillary both articulate just above the vomer and cover it entirely.

Ethmoid.—The anterior dorsal portion of the ethmoid (Fig. 1, 6, *eth*) is strongly keeled, while the posterior portion is concave longitudinally and ends between the frontals where it tapers to a point. There is a narrow median ridge on the keeled portion extending its full length with a V-shaped slit in the anterior end. The ventro-lateral depression of the anterior portion forms a cavity between it and the prefrontal, these parts forming the ventral and mesial osseous walls of the nasal pit. The longitudinal groove in the concave portion is formed by a dorso-lateral expansion on either side at its anterior end. From this point the groove passes caudad and continues as the rectangular groove between the ridges of the frontals. The sides of the posterior portion are concave from the point at which the lateral expansions ex-

tend out from the median line. On each side of the lateral concave surfaces there is a deep pit produced by several pores.

Prefrontal.—The paired prefrontals or ectethmoids Fig. 1, 6, *pfr*) are lateral to the ethmoid and anterior to the frontals. Each is a lateral expansion from the ethmoid and the frontals, having a broad base-like portion and a wing-like process extending from it which forms the anterior boundary of the orbit. The anterior portion is somewhat lower than the rest and appears as a shelf at the side of the ethmoid because of a depression on its anterior dorsal surface. This depression, together with a similar depression on the latero-ventral surface of the ethmoid forms a part of the bony wall of the nasal pit. The wing-like process is narrow antero-posteriorly but broad and flattened dorso-ventrally. The end is rounded and forms a facet for articulation with the palatal and the first exorbital bone. A small ventral process on the wing meets a process from the palatine. From the base of the wing-like portion the bone flattens out antero-posteriorly as it extends ventro-mesad to its articulation with the parasphenoid. There is a foramen through the wing near its suture with the ethmoid through which the olfactory nerve and the orbito-nasal vein and artery to the nasal pit pass. Above the point where the prefrontal unites with the parasphenoid they come in contact with each other in the median line holding between them the ventral edge of the cartilaginous orbito-sphenoid which extends dorsad and caudad forming a partial partition between the orbits.

Frontal.—The paired frontals (Figs. 1, 6, *fr*) form the greater part of the dorsal surface of the cranium. At the anterior end of each there is a small groove produced by pores in the bone. The lateral edges of the posterior portion form the mesial boundaries of the orbits. The posterior portion broadens and forms the posterior and dorsal boundaries of the orbits. At this point the frontals are slightly rounded dorsad and the bone is somewhat porous, possessing several striations which start at the posterior boundary of the orbit and radiate caudad and mesad toward the median line to the parietal bones. The lateral edges of the posterior portion form the mesial border of the anterior part of the temporal fossa. At the lateral edge on the posterior border of the orbit the frontal unites with the sphenotic. Its lateral edge rests on the prefrontal and the mesial edge rests on the ethmoid. In the median line on the ventral surface there is a cartilaginous orbito-sphenoid bone, extending to the parasphenoid and forming a partial partition between the orbits. The ventral surface of the roof of the orbit is filled with large pores and two deep grooves which become deeper as they pass caudad into the deeper part of the frontal. The mesial edge of the inner groove forms a large flange which projects

ventrad along the lateral edge of the brain case. The outer edge of this flange narrows down and, as it passes ventrad, it is drawn out to a thin process; this flange and the thin process clasp the small alisphenoid between them as in *Scorpaena* described by Allis. The ventral surface of the posterior portion is smooth and in connection with supra-occipital which forms a plate beneath the parietals and posterior part of the frontals forms the roof of the brain case.

Postfrontal.—The postfrontal (Fig. 1, *pfo*) is a small tube-like bone similar to the one described by Allis in *Scorpaena scorpus* except that it is without spines. It lies on the part of the dorsal surface of the sphenotic which is not covered by the frontal and pterotic. The tube extends from the lateral edge of the sphenotic caudo-mesad to the anterior end of the temporal fossa.

Sphenotic.—The sphenotics (Figs. 1, 6, *spo*) are located at the lateral margins of the cranium, just posterior to the orbits and, in conjunction with the lateral expansions of the frontals they form the posterior boundary of the orbit. The dorsal surface of each is nearly flat, except for a groove formed for the postfrontal bone which lies within it. It thus forms supports for the frontal, the postfrontal, and the pterotic. It forms the anterior, lateral, and ventral portions of the cranium. The anterior margin borders on the orbit and the ventro-lateral edge forms a facet for the articulation with the anterior head of the hyomandibular. Directly dorso-anterior to the facet is a roughened surface which serves for the attachment of one of the palatal muscles. Dorso-posterior to the facet is a depression, the dilatator fossa, the posterior part of the sphenotic forming the anterior part of the depression. Between the dorsal part of the sphenotic and the frontal, beneath the postfrontal, there is a small foramen which transmits one of the branches of the otic vessels. The sphenotic also forms a part of the internal brain case; the internal surface is smooth and has two depressions, separated by a thin partition of bone which extends mesad into the brain cavity.

Proötic.—The proötic (Fig. 6, *pro*) forms a large part of the lateral surface of the cranium. It is bounded dorsally by the sphenotic and pterotic, anteriorly by the alisphenoid and the dorso-lateral process of the parasphenoid, ventrally by the parasphenoid, and posteriorly by the basi-occipital and exoccipital. Mesially it articulates with the basisphenoid and the proötic of the opposite side. On the ventral surface it is overlapped by the lateral edges of the posterior portion of the parasphenoid. The proötics form the lateral walls of the brain case and also the roof and walls of the myodome. The brain cavity and the myodome are separated by a mesial longitudinal partition-like process which unites with a similar one from the opposite side in the median line. This partition begins at the basioccipital, which also forms the

posterior part of the floor of the brain case, and extends dorso-cephalad until it reaches the processes which support the T-shaped basisphenoid, leaving a small wedge-shaped slit between the basisphenoid and the partition for the opening of the pituitary body from the brain case. Near the lateral wall, just posterior to the process which supports the basisphenoid, a small foramen for the sixth nerve preforates the partition. Between the proötic, alisphenoid, and the dorso-lateral process of the parasphenoid there is a large foramen through which the anterior cerebral vein, the ciliary nerve, and ciliary artery pass. On the front edge of the foramen and slightly mesad, at the base of the process supporting the basisphenoid, there is a second small foramen for the third nerve. On the lateral surface of the proötic is the proötic arcade, which is located slightly dorso-posterior to the foramen between the bones just described and directly ventral to the anterior articular facet for the hyomandibular on the sphenotic. This arcade partly shelters two foramina. The anterior and larger one is for the passage of the jugular vein, the external carotid artery, the fifth and part of the seventh nerves. The posterior one is for the hyomandibular part of the seventh nerve. There is another small foramen for the fourth nerve just anterior to the arcade. The arcade forms an arch through which the jugular vein and external carotid artery pass after they have passed through the foramen. On the inner surface the brain case is smooth with a large broad ridge, produced by the broad groove on the external surface, extending from near the middle just behind the arcade to the posterior end of the bone (where it unites by suture with the exoccipital and the ventral most edge of the pterotic) and continuing caudad as the ridge on the exoccipital. Directly ventral to the ridge on the internal surface, there is a deep depression or groove parallel to the ridge and extending the length of it bordering on the floor of the brain case. This groove continues caudad into the basioccipital where it finally forms a recess with the overhanging edge of the exoccipital. Directly beneath the arcade there is a flange-like process extending from the floor of the brain case to the dorsal edge of the bone where it unites with a similar process of the sphenotic. This flange-like process forms two recesses for parts of the anterior semicircular canal.

Alisphenoid.—The alisphenoids (Fig. 6, *als*) are small, irregular bones, ventral to the articulation of the sphenotic and frontal where they are held in place by the clasp of the ventral flange and slender ventro-mesal process of the frontal. Each also comes in contact, ventrad and caudad, with the parasphenoid and proötic. The outer surface is porous while the inner surface is smooth and forms the latero-anterior part of the brain case. A large foramen, postero-ventral to the alisphenoid, and between it and the proötic and the dorso-lateral process of

the parasphenoid, allows the passage of the anterior cerebral vein, the ciliary artery, and the ciliary nerve. Allis ('09) found a small foramen for the anterior cerebral vein perforating the alisphenoid in *Scomber, Cottus, Trigla, Peristedion, Dactylopterus,* and *Scorpaena* and states that Allen (1905) did not describe it in *Ophidon.* I do not find a foramen perforating the alisphenoid in *Ophidon* nor in *Scorpionichthys.* The anterior cerebral vein, according to Allen (1905), passes through the foramen formed by the proötic, the dorso-lateral process of the parasphenoid, and the posterior edge of the alisphenoid.

Parasphenoid.—The parasphenoid (Fig. 6, *ps*) is the longest bone of the skull and forms the ventral surface of the entire length of the cranium with the exception of the process of the vomer which passes caudad into the parasphenoid. The anterior portion is almost perfectly straight on the ventral surface while the posterior portion is slightly curved upward and the edges of the bone turn up dorso-laterally, the entire length of the bone. In the middle portion the edge projects upward as a long process which extends dorso-laterally to the edge of the alisphenoid. Directly posterior to the process, in the angle between it and the proötic, is a foramen through for the internal carotid artery. The bone has a concave longitudinal groove the entire length of the dorsal surface which, in the anterior portion, is divided by a tall partition, extending from a point immediately anterior to the tall processes to the anterior end of the bone where it terminates in the ethmoid and the vomer. At the anterior end there is a V-shaped slit on the ventral edge for the postero-ventral process of the vomer. The posterior end also has a V-shaped slit extending cephalad, forming the posterior opening of the myodome. The dorsal surface of the posterior portion forms a part of the floor of the myodome, between the proötics and the two tall dorso-lateral processes of the bone itself. This portion also forms a support for the proötics and the basioccipital.

Basisphenoid.—The basisphenoid (Fig. 6, *bs*) is a T-shaped bone forming the anterior part of the roof of the myodome, being attached to the processes extending mesad from the proötic, just postero-ventrad to the alisphenoid. The pedicle is curved ventro-cephalad to the parasphenoid where it is united to it by a bulb of cartilage. It is laterally flattened and the rest of the bone between the proötic processes is dorsally flattened but rounded ventrally and slightly curved cephalad at the point where the pedicle process projects.

Pterotic.—The pterotics (Figs. 1, 6, *pto*) form the lateral edges of the dorsal surface of the skull, posterior to the sphenotics and the postfrontals, and also the lateral borders of the temporal fossa. On the dorsal edge of such there is a narrow ridge extending from the anterior end to beyond the middle from which the surface gradually slopes to

the lateral edge of the skull. A foramen for a lateral line canal occurs at the posterior end; the whole surface being more or less perforated. The lateral surface of the pterotic is bounded cephalad by the sphenotic and the proötic and ventrally by the proötic, exoccipital, and opisthotic. At the anterior end of the bone there is a depression which forms the posterior edge of the dilatator fossa and immediately posterior and slightly dorsal to the fossa is a facet for the articulation of the posterior head of the hyomandibular. Posterior to the facet is a broad shallow groove, the dorsal edge forming the edge of the groove, extending to the posterior end of the bone, where it narrows as does the bone itself. Ventro-caudad to the facet are two or three, more or less developed ridges, extending from the lower edge of the facet to the ventro-posterior edge of the bone where it unites by suture with the opisthotic. The ventral edge of the bone curves sharply inward, thus forming a broad rounded ridge between the facet and the point where it unites with the proötic and the exoccipital. The antero-ventral edge of the facet forms a flange-like shelf beneath which there is a slight depression forming, together with a flange-like expansion of the proötic, a broad groove extending from that point antero-ventrad on to the proötic. The inner surface of the pterotic forms the dorso-posterior part of the lateral wall of the brain case, there being a large cavity passing latero-caudad from the main portion of the brain case, and lying ventro-mesad to the facet of the hyomandibular. This cavity harbors a part of the external semicircular canal.

Epiotic.—The epiotics (Fig. 1, *epo*) form a part of the dorsal surface of the cranium. The lateral surface of each forms the mesial boundary of the temporal fossa; its mesial edge forms the lateral border of the supra-temporal pocket. The bone is bounded laterally by the posterior process of the parietal and pterotic; ventrally and postero-ventrally by the exoccipital and mesially by the supra-occipital. It forms a tall ridge extending postero-laterad as far caudad as the pterotic and the opisthotic above the exoccipital, and nearly parallel to the pterotic. The supra-scapular lies on the dorsal surfaces at the caudal ends of the epiotic and pterotic, thus forming a roof at the posterior end of the temporal fossa. At the anterior end the bones are overlapped by the supra-occipital and the parietals. The internal surface forms the dorso-caudal wall of the brain case. These parts form posteriorly pockets for the posterior semicircular canals, directly above and in connection with the exoccipital.

Parietal.—The parietals (Fig. 1, *p*) form a part of the dorsal surface of the cranium, their lateral edges forming the mesial borders of the temporal fossa. Each is somewhat irregular in shape with its broadened end cephalad and a long slender process, extending

caudad slightly dorsad and laterad on the epiotic ridge, which in this position projects over and forms a part of the roof of the temporal fossa. At the posterior end of the process there is a foramen, passing cephalad into the bone for one of the lateral line canals. The process forms a ridge and extends antero-mesad, uniting with a similar ridge from the opposite side in the median line. The dorsal surface of the ridge is porous and possesses several striations parallel with the ridge. At the anterior end the bone joins by suture with the frontal; it is supported laterally by the pterotic and mesially and ventrally by the epiotic and supra-occipital. In the suture between the parietal and supra-occipital on each side of the median line is a foramen for the ramus lateralis accessorius vessels. The inner surface of the bone lies largely on the dorsal surface of the supra-occipital, but lateral to the plate-like supra-occipital, which covers the greater part of the cranial cavity; the parietal forms a part of the dorsal surface of the cavity where it arches over the space between supra-occipital and pterotic.

Opisthotic.—The opisthotic (Fig. 6, *opo*) is a small plate-like bone, oval in outline, lying between the pterotic and the exoccipital. The antero-dorsal edge overlaps the postero-ventral edge of the pterotic and the ventral edge overlaps the exoccipital, thus forming the latero-caudal edge of the skull. It is drawn out caudad into a rounded process which projects beyond the exoccipital and even with the pterotic. The opisthotic forms the posterior lateral wall of the temporal fossa, from the point of its union with the pterotic on the mesial surface. The posterior end of the bone has a bulb-like appearance and is united by a cartilaginous ligament to the suprascapular.

Exoccipital.—The exoccipitals (Figs. 1, 6, 8, *eo*) are irregular bones which form a part of the lateral and of the posterior surface of the cranium and of the brain case. A well defined angle, ventral to the opisthotic, separates the lateral from the candal surfaces. That part which forms the porterior portion lies directly below the epiotic and a part of it forms the base of the epiotic ridge. The dorsal edge also borders on and forms the posterior edge of the floor of the temporal fossa. That part posterior to the angle extends backward and forms a rounded head, the occipital condyle, which looks caudad and slightly ventrad, articulating with an anterior process of the first vertebra. The two condyles are dorso-laterad to the basioccipital and laterad to the foramen magnum. Ventrad to the epiotic ridge and the temporal fossa, the bone extends caudad and mesad, uniting in the median line with its fellow of the opposite side; thus forming the roof of the medulla oblongata. It is overlapped in the median line by a ventro-posterior process of the supra-occipital. Slightly above the angle separating the posterior and lateral surfaces, there is a small depression

or groove, dorso-cephalad to the condyle, extending upward to the posterior end of the temporal fossa. The lateral surface of the bone is irregular in shape and possesses a broad deep groove extending from slightly cephalad of the angle separating the lateral and posterior surfaces to about the middle of the proötic. At the posterior end of the groove there is the foramen for the vagus nerve and slightly anterior to this, another foramen for the glossopharyngeus nerve perforates the bone in the same groove. On the posterior, dorsal surface, anterior to the condyle, are two foramina for the passage of the occipital nerves. The internal surface forms part of the posterior and part of the lateral walls of the brain case and the dorsal wall of the medulla oblongata. The ventro-mesial edge, overlapping the basioccipital, forms a lateral recess with the groove of the basioccipital on each side of the cavum sinus imparis. Dorsal to this recess, a larger cavity which lies slightly dorso-cephalad to the vagus foramen, lodges the ampulla of the posterior semicircular canal. The exoccipital unites cephalad with the proötic, ventrad with the basioccipital, dorsad with the opisthotic and epiotic, and mesad with its fellow from the opposite side and the supra-occipital.

Supraoccipital.—The supraoccipital (Figs. 1, 8, *so*) forms the dorso-posterior portion of the skull, lying between the epiotics, with a process between the exoccipitals, and also beneath the parietals and the posterior part of the frontals, thus forming the roof of the brain case as well as a part of the posterior wall. Between the epiotics it has a deep groove, extending from the dorsal surface, postero-ventrad, almost to the foramen magnum, where it ends in a process between the exoccipitals. The groove, the supra-temporal pocket, is formed by a process on either side which overlaps the epiotics. On the dorsal surface it has a small longitudinal crest in the median line extending cephalad from the anterior end of the groove to the point where the bone is overlapped by the parietals. The inner surface forms the roof of the brain case as it has developed into a thin plate-like bone beneath the parietals and the posterior part of the frontals. It has a smooth surface with a ridge at the posterior end extending postero-ventrad from the dorsal surface toward the foramen magnum. Beneath the point of articulation with the parietals and frontals a small flange is developed on the ventral surface near the lateral margin which extends latero-cephalad, and unites with a similar flange from the sphenotic by a cartilaginous ligament. In the base of the flange is a foramen for the ramus lateralis accessorius vessel which passes over the supra-occipital between it and the parietal.

Basioccipital.—The basioccipital (Figs. 1, 6, 8, *bo*) forms the ventro-posterior end of the cranium, the posterior end of the myodome,

and the posterior part of the floor of the brain cavity. On its dorsal surface (floor of the brain case) are two longitudinal grooves, one on each side of the median line, lying along the lateral walls of the bone and separated by a rounded ridge in the median line. These grooves are open throughout the anterior half but are covered in the posterior half by the edges of the exoccipitals which overlap into the brain cavity and with the groove form recesses on each side as it passes backwards on each side of the pit of the cavum sinus imparis, reaching almost to the conical, vertebra-like, depression on the posterior end. The cavum sinus imparis is a deep pit on the dorsal surface in the median line near the posterior end, only separated by a single thickness of bone from the conical, vertebra-like, depression. This pit lies on the surface of the median rounded ridge between the lateral grooves which form the recesses in connection with the overlapping mesial edges of the exoccipitals. As the cavum sinus imparis passes backward it gradually becomes deeper until it forms a saccular cavity at the posterior end. The ventral surface of the bone possesses a long groove the ventro-lateral edges of which almost form a circle in connection with the parasphenoid. This groove tapers gradually into a narrow tube which passes to the posterior end and opens to the exterior by a slit-like opening on the ventral surface. This tube forms the posterior portion of the myodome. On the lateral surface of the bone is a rounded ridge, arising at the dorso-anterior edge, where it is a continuation of a similar ridge from the proötic, and extending postero-ventrad nearly to the ventral surface of the bone. The posterior end is rounded, with a slight conical depression which forms the facet for the articulation with the first vertebra.

Myodome.—The myodome is a long funnel shaped cavity, formed by the basisphenoid, the two proötics, the parasphenoid, and the basioccipital. The funnel is triangular in outline, located between the two proötics and ventral to the basisphenoid, the pedicle of which bisects the anterior end of the cavity. It becomes narrow as it extends caudad into the basioccipital where it tapers to a tube and opens to the exterior by a slit on the ventral surface. There is an oval opening between the basisphenoid and the partition of the proötics for the pituitary body. Immediately posterior to this opening on the dorso-lateral surface of the myodome there is a pocket which extends upward toward the trigemino-facial chamber and is only separated from it by a thin partition. Here the myodome is widest and narrows rapidly caudad until it forms the tube. At the median ventral edges of proötics and basioccipital is a long slit-like opening, the hypophysial fenestra, covered by the parasphenoid, except at the posterior end where it opens to the exterior. The myodome contains the eye muscles, which are attached to the walls and roof of the cavity and pass cephalad into the orbit.

Orbit.—The orbits are formed by the prefrontals, frontals, sphenotics, and suborbitals. They are large in *Ophidon* and the two are separated by the partial partition of the orbitosphenoid which is cartilaginous at its anterior portion and membranous at the posterior. At the anterior end the partition comes in contact with the prefrontals in the median line and at the posterior end it comes in contact with the dorsal surface of the basisphenoid and the pedicle unites with the membrane at the point of contact with the parasphenoid. Dorsal to the basisphenoid the membranous partition divides, extends laterally and unites on each side with the ventro-mesial edge of the alisphenoid and the ventral processes of the frontal, thus forming the posterior wall of the orbit and the anterior wall of the brain cavity. Directly dorsal to the basisphenoid and slightly lateral to the median line there is an opening through the membrane for the passage of the optic nerve. Above the openings for the optic nerves in the median line against the dorsal wall there is an opening for the olfactory nerves which pass cephalad and divide, one passing on either side of the partition and through the foramina in the prefrontal into the nasal sac.

Brain Cavity.—The brain cavity in *Ophidon* is quite large and extends from the posterior end of the orbit, from which it is separated by the lateral partitions of the infraorbital membrane, to the posterior wall of the cranium. The cavity has a series of recesses on the dorso-lateral walls for parts of the brain and on the ventral surface there is a groove like cavity, the cavum sinus imparis, beneath the foramen magnum. On the floor of the brain case are two grooves which extend caudad along the lateral walls of the basioccipital, parallel to the cavum sinus imparis to the posterior end. The mesial edges of the exoccipitals overlap and form saccular recesses of these grooves. Above each saccular recess there is a cavity—the part of the labyrinth enclosing that portion of the posterior semicircular canal which is located in the exoccipital. Dorsal to this is a large recess in the epiotic which is for the rest of the posterior semicircular canal. Antero-lateral to this recess in the pterotic there is a large recess for the external semicircular canal, with two pits in the ventral surface for the ampulla of this canal. One of these pits is located in the proötic and the other in the pterotic. Anterior to this recess there is another for the anterior semi-circular canal. This one is divided into two parts by a flange-like partition which extends dorso-cephalad from the floor of the cavity. The anterior part of the cavity lies in the proötic and lodges the ampulla, while the posterior lies in the sphenotic and lodges the body of the canal. Directly anterior to the anterior semicircular canal there is another shallow cavity—the trigemino-facial chamber—which lies nearly in the line with the pituitary opening between the basisphenoid and the proötics. The dorso-anterior

end of the brain case is located between the ventral flanges of the frontals.

Facial Bones

Premaxillary.—The premaxillary (Fig 9) is a long curved bone bearing teeth. Its anterior end is thickened and bears two dorsal processes extending dorso-caudad, with a V-shaped slit between them. The anterior process is long, slender, and laterally flattened at the base and gradually becomes rounded distally until at its end, where it articulates with the ethmoid, it is antero-posteriorly flattened. The posterior process is broad and thick at the base and as it nears the end it makes a sharp curve and comes to a point at its anterior edge; on its anterior mesial surface it has a deep depression into which an angular process of the maxilla passes as it articulates with that bone. It is rounded on its dorso-lateral surface except at a point slightly posterior to the middle where it has broadened and flattened into a sharp edge; from this point it gradually tapers to a long slender point which extends on the lateral surface of the mandible. The anterior end of the bone, anterior to the processes, is rounded and thickened as it nears the median line where it unites with its fellow from the opposite side. Two kinds of teeth are present on the premaxillary, an inner row of canine-shaped teeth and from one to several irregular rows of the villiform type.

Maxillary.—The maxillary is a long curved bone without teeth, having a thick articular head and a flat expanded hind end. The former has a large articular facet which appears double on account of a V between its articular surfaces. The antero-mesial of these processes curves mesad and lies inside of the dorsal process of the premaxillary with which it articulates, directly dorsal to the dorsal limb of the vomer. The antero-lateral process is drawn out into a pointed projection lateral to the process of the premaxillary with which the other process articulates, and upon which the anterior ends of the nasal and palatine bones rest. At the apex of the V between the articular processes, the bone is rounded mesad at the point where it fits over the process of the premaxillary. The ventral edge of the first suborbital rests on the dorsal surface of the maxilla for some distance back from the anterior end. The posterior flattened and broadened end rests on the lateral edge of the mandible as it passes postero-ventrally from the anterior end.

Nasal.—The nasal is a small bone connecting the prefrontal, ethmoid, and the maxilla and forming the roof of the nasal pit. It is Y-shaped, with one edge of the broad end lying on a small process on the dorso-anterior edge of the prefrontal and the other on the antero-lateral process of the ethmoid. The pedicle extends cephalad and rests upon the maxilla, thus forming the roof of the nasal pit.

Suborbitals.—The suborbital bones, three in number, lie on the lateral surface of the skull. The anterior end of the series is firmly attached to the dorsal edges of the palatine and maxillary, also articulated with the prefrontal at its lateral facet. At the posterior end the third bone is attached to the preopercular, thus forming a bridge from the anterior to the posterior ends across the cheek; and also the ventral boundary of the orbit. The suborbitals are plate-like bones. The anterior bone is broad, somewhat oval in shape, lying on the surface of the maxillary for some distance from the anterior end. Caudad it is united with the second suborbital bone. The second bone is elongate in shape and about one-half as broad as the anterior one. This bone really forms the ventral boundary of the orbit. The third bone is the longest and passes from the edge of the orbit and is extended caudad, forming the suborbital stay. It is elongate, and is slightly broadened at the posterior end. Near the anterior end of this bone is a small postorbital, forming the posterior edge of the orbit and extending to the edge of the sphenotic. In younger specimens this is merely a cartilage but in more mature forms it becomes ossified. This is a small plate-like bone lying in the dermal tissue.

Palatine.—The palatine is an irregular bone composed of two portions, a broad plate and an anterior rod. The plate is posterior and is somewhat triangular with the apex pointing caudad. On the lateral surface it is smooth except for some small narrow ridges which extend postero-ventrad from the dorso-anterior end. There is a large facet on the dorsal edge for the articulation with the prefrontal and with an edge of the first suborbital. This facet has a deep pit which extends as a groove on the dorsal edge to the posterior end, and serves for the articulation of the mesapterygoid. The mesial edge of the facet is extended dorsally into a tall process which becomes attached to the ventral edge of the prefrontal. The mesial surface of the palatine is roughened by porous openings and bears a deep groove bounded by the dorso-mesial and the ventro-mesial edges of the bone extending from the anterior end of the posterior portion to the posterior end of the bone. Two kinds of teeth are present on the ventral surface which are like those on the vomer and premaxillary—an inner row of large teeth of the canine variety and outer row of small villiform type, more or less irregularly arranged. The anterior rod-shaped part of the bone is somewhat curved antero-ventro-laterally from the dorsal edge of the triangular portion, directly anterior to the articular facet of the prefrontal and the suborbital bone. This rod is somewhat flattened dorso-ventrally at the anterior end where it articulates by a ligament with the dorsal surface of the maxillary on the antero-lateral process of the head of that bone.

Mesapterygoid.—The mesapterygoid, the ectopterygoid of some authors, is a long, slender, curved bone which unites the palatine with the quadrate. The anterior end of the mesapterygoid lies in the groove on the dorsal edge of the palatine, from there it passes caudad for a distance, then it curves ventrally and articulates with the anterior edge of the quadrate. It is flattened laterally at the posterior and middle parts but at the anterior end it is flattened dorso-ventrally. There is a small groove on the ventral edge where it lies in a groove on the dorsal edge of the palatine. On the dorsal edge of the mesapterygoid there is a long slender groove for a membranous bone, the entopterygoid, which forms a part of the ventral boundary of the orbit. At the point where the bone curves ventrally there is a plate-like process on the dorsal edge which connects with the mesapterygoid and the entopterygoid. On the posterior edge the bone possesses a slight groove where it unites with the quadrate. The bone tapers to a point at its postero-ventral end.

Hyomandibular.—The hyomandibular is shaped like an arrow head with the shank extending from the ventral edge. The anterior end is drawn out into a thin, pointed, plate-like process. Slightly dorso-caudad to the pointed end is a thickened part which passes ventro-caudad across the middle of the head and also across the shank, thus forming an irregular cross with the shank. At the anterior end of the bar forming the cross is a facet, the anterior head of which articulates with the facet of the sphenotic directly above the proötic arcade. On the posterior end of the cross bar there is a facet for the articulation with the opercular. The shank passes upward through the body of the bone and forms a double facet, the posterior head of which articulates with the facet of the pterotic immediately posterior to the dilatator fossa. The dorso-caudad part of the posterior head articulates with a flange-like process dorso-caudad to the facet. The long shank extends ventrally and is united to the symplectic at its ventral end by a mass of cartilage. The metapterygoid articulates with the anterior process of the hyomandibular which is a thin membrane bone filling the space between the anterior bar of the cross and the shank. Likewise the spaces between the other bars are also filled with a thin sheet of membrane bone, thus leaving slight depressions between the bars. There is a deep pit on the mesial surface at the angle between the anterior bar and the shank, which gives rise to two canals. One passes ventrally into the bone and opens on the lateral surface of the shank just anterior to the ridge which bounds the groove for the articulation of the preopercular. This canal bears the truncus hyoideo-mandibularis facialis vessel. The other canal passes ventrad and caudad, dividing into two parts; one opens to the exterior at the dorsal edge of the groove for the articulation

of the preopercular and between the opercular bar and the shank, the other opens at the hind edge of the bone, directly beneath the opercular bar. These two canals transmit branches of the nerve of the latero-sensory canal which lies in the region of the opercular. Another small foramen, in the dorsal edge of the groove for the preopercular, transmits a part of the hyoid nerve between the hyomandibular and the preopercular.

Symplectic.—The symplectic is a small paddle-shaped bone with a broadened end and a long slender process. It articulates at its dorsal and broadened end with the shank of the hyomandibular by a long cartilaginous ligament. The bone for the most part lies in a triangular groove on the lateral surface of the quadrate with its long process penetrating the bone almost to its articulating facet for the mandible.

Metapterygoid.—The metapterygoid is a broad plate-like bone, more or less quadrant shaped with two plate-like processes. The quadrant-shaped part is the ventral portion of the bone with the round edge united by a cartilaginous ligament with the dorsal edge of the quadrate. Two processes extend from the dorsal edge of the quadrant. One of these is somewhat elongated and extends dorso-cephalad coming in contact with the anterior process of the hyomandibular. The other extends caudad from the dorso-posterior edge of the quadrant, and bears a V-shaped slit for the hyoid artery on its ventral edge. The posterior edge comes in contact with the anterior edge of the shank of the hyomandibular. Two small flanges, one on either surface of the anterior process, bound a groove on the dorsal edge which extends nearly the entire length of the process. The groove is for the union with the hyomandibular.

Quadrate.—The quadrate is a quadrant-shaped bone with the ventral point thickened and formed into a head for the articulation of the articular. The dorsal or rounded edge is broken near the posterior edge where the bone forms a deep groove on the inner surface for the articulation of the symplectic where it passes downward into the quadrate. There is a groove on the posterior edge extending almost the length of the bone for the contact with the preopercular. The anterior edge is somewhat roughened and possesses no groove where it articulates with the mesapterygoid. On the dorsal edge the quadrate unites by a cartilaginous ligament with the ventral edge of the metapterygoid and cephalad with the entopterygoid and mesapterygoid, caudad it unites with the preopercular and the symplectic.

Preopercular.—The preopercular (Fig. 4) is a long, flat, curved bone with three small barbs on its posterior side. A lateral line sensory canal runs throughout its length, opening near the edge of the ventral barb and at the dorsal tip of the bone. There are also other

sensory canals in the bone with openings at various points. The outer surface is smooth except that it has a narrow ridge at its postero-lateral edge which is located slightly anterior to the spines. The notch or pit formed by the curve is filled with a thin wavy sheet of bone which slightly overlaps the caudal edge of the shank of the hyomandibular. Slightly dorso-anterior to the ridge is a small roughened area for the articulation of the suborbital stay.

Mandible.—The mandible is made up of three bones, the dentary, articular and the angular. A broad rounded ridge runs from slightly anterior to the head of the articular nearly to the anterior end of the dentary. On the inner surface of the dentary is a cavity within the bone corresponding to the ridge on the exterior; the articular has no cavity but a groove which corresponds to the ridge. In the bone beneath the ridge there is a latero-sensory canal which extends from the anterior end of the dentary to the posterior end of the articular. The dentary is a long bone with two long processes at the posterior end, forming a V-shaped angle which fits over the anterior process of the articular for its articulation with that bone. The lower surface is broadened by a mesial extension of a plate-like bone forming the ventral surface. Two kinds of teeth are present on the dentary, an inner row of the large canine type and several irregular rows of the villiform variety.

Articular.—The articular is united to the dentary by several bands where it fits into the V-shaped angle for the union of the two bones. This bone has a large facet for articulation with the quadrate. Here the bone is quite broad and gives off three processes. Slightly anterior to the facet it gives off a dorsal anterior process which unites with the dorsal process of the dentary by a cartilage. Immediately ventrad to this, and anterior to the facet, it gives off a long process, the anterior end of which fits into the V-shaped angle of the dentary. On the ventro-anterior edge it gives off the third process which fits over the ventral process of the dentary. There is a groove on the inner surface of the anterior and ventral processes and a deep pit on the antero-ventral edge of the facet. Ventro-posterior to the facet is located the angular bone which serves as an attachment for some of the mandibular muscles to the quadrate and also to the intraopercular.

SCORPIONICHTHYS MARMORATUS

The Cranium

The skull (Figs. 2, 5) of *Scorpionichthys* differs from that of *Ophidon* only in a few points. The dorsal surface is somewhat more rounded and is covered with a granulated network. The temporal fossae are slightly different in shape and the orbits are smaller and more circular in outline, also the surface between them is narrower and concave. On the dorsal surface of the ethmoid the longitudinal groove, present in *Ophidon,* does not occur and a large erect process extending antero-laterally from the median line takes the place of the small ethmoid processes. There is a broad flange on the posterior end of the skull extending mesad from the caudal end of the epiotic ridge toward the median line, also the supra-occipital possesses a crest on the posterior surface extending from the dorsal edge to the end of the postero-ventral process. The anterior end of the temporal fossa is formed mainly by the edges of the granulated network of the parietals and pterotic. The parietal projects over the fossa for a distance as also does the epiotic which goes to make up a part of the mesial edge of the roof. Most of the roof is formed by the extra-scapular lying on the dorsal surfaces of the epiotic and pterotic across the fossa. In the dilatator fossa the sphenotic forms the greater part of the roof, in contrast to the condition in *Ophidon;* also there are no foramina in the fossa for the passage of the branches of the otic vessels.

The vomer (Figs. 2, 5 *v*) is relatively smaller than in *Ophidon* but has the same general shape except that the lateral expansions are not as long and the dorsal process is shorter. Only villiform teeth are present; they are numerous and irregularly arranged. The dorso-anterior surface, slightly lateral to the median line, possesses a small articular facet for the articulation with a similar facet on the mesial edge of the maxilla.

The ethmoid (Figs. 2, 5, *eth*) has no depression on its lateral surfaces for the nasal pit. A tall antero-lateral process forms a V-shaped crest in the median line, supporting the nasal bones which roof the pit.

The prefrontals (Figs. 2, 5, *pfr*) are relatively large, especially anteriorly; they lack depressions for the nasal pits. A thin flange extends ventro-caudad from the ventral surface of the lateral edge of the wing-like expansions to the mesial portion where it unites with the parasphenoid in the median line. On the lateral edge of the anterior portion, directly posterior to the vomer and anterior to the wing, there is a small facet for the articulation with the palatine.

The frontals (Figs. 2, 5, *fr*) are somewhat shorter than in *Ophidon* and the surface between the orbits is markedly concave. The frontals unite with the sphenotics in the usual position and form a part of the orbit. The surface directly posterior to the orbit is somewhat depressed and forms a ridge on the ventral surface in the posterior part of the orbit. On the dorsal surface of the posterior portion of the bone there is a granulated network arranged more or less in longitudinal ridges with an irregular groove in the median line bounded by granulated ridges. The ventral surface is comparatively smooth and the part within the orbit is not porous as in *Ophidon*. There is a single ventral flange-like process on each side of the median line forming a part of the anterior boundary of the brain case. At the caudal end the flange is thickened and unites with the alisphenoid. A ridge extends from this point laterad to the edge of the bone at the place where it unites with the sphenotic, forming a triangular pit between the ridge and the anterior edge of the latter bone. There is also a small depression anterior to the ridge between it and the flange. In some specimens the flange comes in contact with the dorso-lateral process of the parasphenoid on the anterior edge of the alisphenoid.

The ventro-posterior edge of the sphenotic (Figs. 2, 5, *spo*), in connection with the dorsal edge of the proötic dorsal to the arcade, forms a facet for the articulation with the anterior head of the hyomandibular. In *Scorpionichthys* the proötic forms nearly half of the facet while in *Ophidon* it forms only a very minor part of it. The sphenotic forms the greater part of the roof of the dilatator fossa, a condition slightly different from *Ophidon* where the pterotic forms the roof.

The pterotic (Figs. 2, 5, *pto*) forms only a small part of the dilitator fossa and has a granulated surface.

The alisphenoid (Fig. 5 *als*) is not porous and is not held between the two ventral processes of the frontal. It lacks a foramen for the passage of the cerebral vein such as Allis ('09) found in *Scorpaena* and others. It forms the dorsal edge of a large foramen which is otherwise bounded by the edges of the proötic and the parasphenoid process.

The basisphenoid and parasphenoid (Fig. 5, *ps*) are the same as in *Ophidon* except that in the parasphenoid there is a small partition between the two dorsal processes which separates the anterior and posterior portions.

The proötic (Figs. 2, 5, *pro*) possesses a flattened process on its dorsal edge; this lies directly ventral to the hyomandibular facets and causes the hyomandibular to extend laterally from the skull. The ventral surface of this process contains a rounded pit which extends dorsad, almost between the hyomandibular facets. On the dorso-anterior edge, immediately dorsal to the arcade, the bone forms a part of the facet

for the anterior head of the hyomandibular. In other respects this bone is like that of *Ophidon* except that the foramen for the external carotid artery, the jugular vein, and parts of the fifth and seventh nerves are located in a pit slightly mesial to the arcade.

The epiotic (Figs. 2, 5, 7, *epo*) is flattened on the dorsal surface and extends caudad into a flattened process which forms a part of the dorsal surface of the cranium. On the meso-posterior edge a flange-like process from the posterior end of the bone extends meso-cephalad to the median line where it unites with a similar process on the supra-occipital. The lateral edges of the epiotics project slightly over the fossa and form a part of the roof.

The parietals (Figs. 2, 5, *p*) have a granulated surface like that of the frontal and pterotic. They lie on the dorsal surface of the supra-occipital and form only a small part of the roof of the brain case at the edges of the supraoccipital. The bones do not meet their whole length in the median line, but leave the supraoccipital exposed.

The supraoccipital (Figs. 2, 7, *so*) has a flange-like process on the posterior surface which is a continuation of that on the epiotic. The flanges of either side fuse in the median line where they come in contact with the crest which extends from the dorsal edge of the bone to the ventral edge of the process. Near the dorsal edge of the skull it forms a slight depression on the caudal surface in connection with the parietal.

The basioccipital (Figs. 2, 5, 7, *bo*) and exoccipitals (Figs. 2, 5, 7, *eo*) are as in *Ophidon*, except that in *Scorpionichthys* the condylar processes and the basioccipital are longer.

Facial Bones

The maxilla is shorter and more flattened throughout its entire length than in *Ophidon*. On its ventro-mesial edge is a small facet for articulation with a similar facet on the dorsal surface of the vomer.

The premaxillary (Fig. 10) is much shorter than in *Ophidon* but the dorsal processes are the same. Only villiform teeth are present which are numerous.

The palatine is similar in all respects except that the mesial process is larger than in *Ophidon*, and only villiform teeth are present.

The hyomandibular has a large flange-like process on the outer surface which extends ventro-posteriorly from the dorso-anterior angle formed by the irregular cross, to nearly the postero-ventral edge of the shank. The shank is broad and flattened throughout and unites with the preopercular, symplectic, and metapterygoid.

The preopercular (Fig. 3) bears two spines, one long and pointed and the other short and somewhat rounded, a condition not found in

Ophidon. The dorsal edge of the bone is drawn out into a long slender process which lies on the posterior edge of the shank of the hyomandibular.

The mandible is shorter than in *Ophidon*. There is no ridge on the lateral surface of the dentary nor is there a cavity within it; also there is no mesial process on the ventral edge. It possesses villiform teeth but there seems to be a modification of the teeth in the inner row. These are longer than the others and have assumed more or less of a canine shape, placing the *Scorpionichthys* and *Ophidon* closer together.

HEXAGRAMMOS DECAGRAMMUS

The Skull

The dorsal surface is smooth and more rounded than either *Ophidon* or *Scorpionichthys,* on account of the lateral extensions of the pterotic and proötic which makes a broad and flat rather than a deep temporal fossa. The supraoccipital is especially conspicuous as it separates the two parietals and comes to a spine-like point. On each side of the median line the parietals form narrow ridges which extend postero-laterally on the lateral edges of the epiotics and form the mesial edges of the roof of the temporal fossa. The dilatator fossae are shallow grooves in the sphenotic and pterotic bones. They lack foramina.

The vomer (Figs. 12, 13) in this species has a relatively longer dorsal process than either *Ophidon* or *Scorpionichthys.* There is no articular facet on the dorso-anterior edge for the maxilla. Only villiform teeth are present.

The ethmoid (Figs. 12, 13) is not grooved but slightly keeled. It has no depressions for the nasal pits and the antero-lateral processes for the support of the nasal bone are similar to those of *Ophidon.*

The prefrontals (Figs. 12, 13) have no depressions on the dorso-anterior edge for the nasal pits and have articular facets on the antero-lateral edges for the palatines as in *Scorpionichthys.*

The frontals have a smooth dorsal surface which is slightly grooved between the orbits. It is not porous on the ventral surface and possesses a single flange process as in *Scorpionichthys,* differing from *Ophidon* and *Scorpionichthys* in not uniting with the sphenotic to form the posterior border of the orbit. As in *Scorpionichthys,* the sphenotic, in connection with the proötic, forms the facet for the anterior head of the hyomandibular.

The pterotic is a thin flange-like bone extending postero-ventrally from the sphenotic, thus forming the ventro-lateral boundary of the temporal fossa.

On the proötic there is a lateral flange-like process ventral to the facets for the hyomandibular; this extends out laterad below the facet for some distance, as in *Scorpionichthys.* The proötic forms a large part of the anterior facet for the hyomandibular. No special peculiarities are shown in the arcade or the location of the foramina.

The parasphenoid has no partition between the lateral processes to separate the anterior and posterior portions and differs from *Ophidon* in that the ventral surface of the anterior portion bears a conspicuous ridge.

The epiotic ends posteriorly in two processes.

The condylar processes of the exoccipitals are relatively longer than in *Ophidon* but not as long as in *Scorpionichthys*.

Facial Bones

The premaxillary is relatively shorter than in *Scorpionichthys* and much shorter than in *Ophidon*. Villiform teeth are present but there is a modififfication of these in the outer row, as they are much heavier and longer than those of the inner rows.

The maxilla has a flange on its dorsal surface where it comes in contact with the first suborbital bone. Posterior to this flange the bone is flattened.

There is a facet on the anterior mesial edge of the palatine where it comes in contact with the ethmoid. Only the villiform teeth are present. The shank of the hyomandibular forms nearly a rectangular cross with the bar which bears the facets for the anterior head and the opercular bone. This causes the shank, which extends ventrally and slightly posteriorly in *Ophidon,* and directly ventral in *Scorpionichthys,* to extend antero-ventrally in this form.

The metapterygoid has a short rounded anterior process and a groove, formed by lateral and mesial flanges, on the posterior edge for the shank of the hyomandibular and the hyoid artery.

There are no particular differences shown in the quadrate except that it is more anterior in this fish than in the other species described, a condition brought about by the position of the hyomandibular shank. The quadrate lies ventral to the anterior edge of the orbit while in *Ophidon* it lies ventral to the posterior edge and in *Scorpionichthys* it is ventral to the central portion of the orbit.

The preopercular lacks barbs and spines and has no grooves nor ridges. It lies postero-ventral on account of the shank of the hyomandibular and the position of the quadrate. On this account the posterior end of the suborbital stay is somewhat lower.

No lateral ridge is present on the mandible and no cavity within the dentary, nor is there a mesial flange on the ventral edge, as in *Ophidon.* The dentary is relatively much shorter than in *Ophidon* and somewhat shorter than in *Scorpionichthys.* Villiform teeth are present but there is a slight modification of those of the outer row. They are longer and much heavier than those of the inner rows.

SUMMARY

Since *Ophidon* and *Hexagrammos* belong to the same family, Hexagrammidae, one might expect something of a similarity in their osteology and also more marked differences between *Scorpionichthys,* belonging to the family Cottidae, and *Ophidon.* From a study of these forms I find that there are more differences between *Ophidon* and *Hexagrammos* than between *Ophidon* and *Scorpionichthys.*

Some of the differences between *Ophidon* and *Hexagrammos* are,—

1. The dorsal surface is more rounded in the latter.
2. The supraoccipital possesses a conspicuous spine-like crest in the median line which entirely separate the parietals in *Hexagrammos.*
3. Foramina are present in the dilatator fossa in *Ophidon* but absent from *Hexagrammos.*
4. In *Hexagrammos* there are no nasal pit depressions on the ethmoid and prefrontal. The ethmoid is but slightly keeled and the anterior portion of the prefrontal possesses a lateral facet.
5. In *Ophidon* the frontal is thick and porous, but in *Hexagrammos,* thin and smooth, with a single flange and a single groove on the ventral surface.
6. The sphenotic does not form part of the posterior edge of the orbit in *Hexagrammos.*
7. In *Ophidon* only a small part of the anterior hyomandibular facet is formed by the proötic, while in *Hexagrammos* this bone forms at least half of it. Also there is a conspicuous lateral proötic process below the hyomandibular facet in the latter genus.
8. In *Ophidon* the hyomandibular shank extends ventro-caudad while in *Hexagrammos* it extends ventro-cephalad, placing the quadrate further cephalad.
9. In *Hexagrammos* the preopercular spines and ridges found in *Ophidon* are absent, and the bone itself occupies a more ventral position.
10. Relatively, the mandible is twice as long in *Ophidon* as in *Hexagrammos* and the dentary possesses no lateral ridge or cavity, nor a mesial flange on the ventral surface.
11. A marked difference is found in the teeth in *Ophidon* and *Hexagrammos.* Both canine and villiform are found in the former but only the villiform in the latter.

Some of the likenesses between *Ophidon* and *Scorpionichthys* are,—

1. Dorsally, both skulls are flattened and have similar temporal fossae.

2. The sphenotic and the frontal bones form the posterior edge of the orbit.

3. The proötic arcade and the location of the formina are identical in both.

4. The alisphenoid and the parasphenoid are alike, with the exception of a small partition between the dorso-lateral processes of the parasphenoid in *Scorpionichthys*.

5. Except for the longer premaxillary in *Ophidon,* the maxilla and the premaxillary are alike in both species.

6. The pterygoids, symplectic, and quadrate are alike in every respect.

7. In *Ophidon,* canine and villiform teeth are present and only villiform in *Scorpionichthys,* but in the latter the inner row of mandibular teeth is better developed.

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EXPLANATION OF PLATES

Abbreviations

als	Alisphenoid	*pfo*	Postfrontal
bo	Basioccipital	*pfr*	Prefrontal
bs	Basisphenoid	*pro*	Prootic
eo	Ex-occipital	*ps*	Parasphenoid
epo	Epiotic	*pto*	Pterotic
eth	Ethmoid	*so*	Supra-occipital
fr	Frontal	*spo*	Sphenotic
opo	Opisthotic	*tf*	Temporal fossa
p	Parietal		

All figures are reproduced from original drawings made by the author from preparations.

PLATE I

EXPLANATION OF PLATE

Fig. 1. Dorsal view of skull of *Ophidon elongatus*. Natural size.

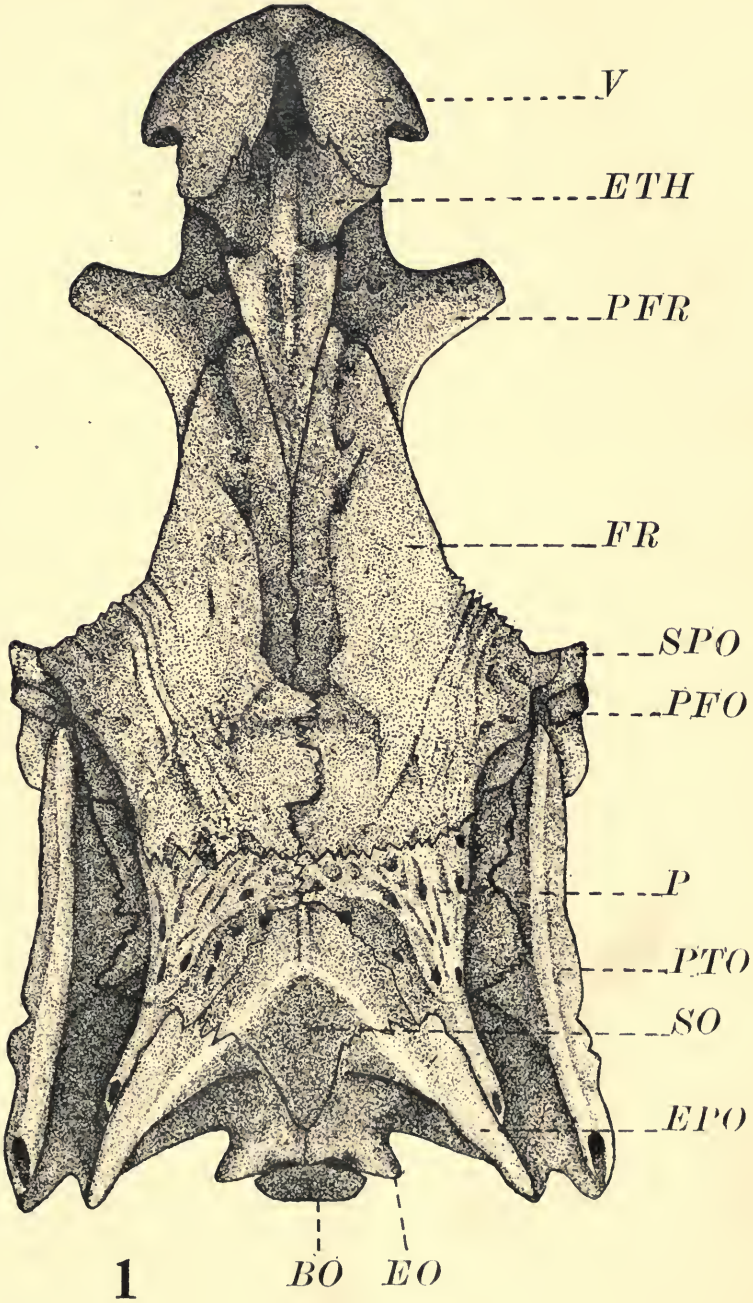

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PLATE I

PLATE II

EXPLANATION OF PLATE

Fig. 2. Dorsal view of skull of *Scorpionichthys marmoratus*. Natural size.

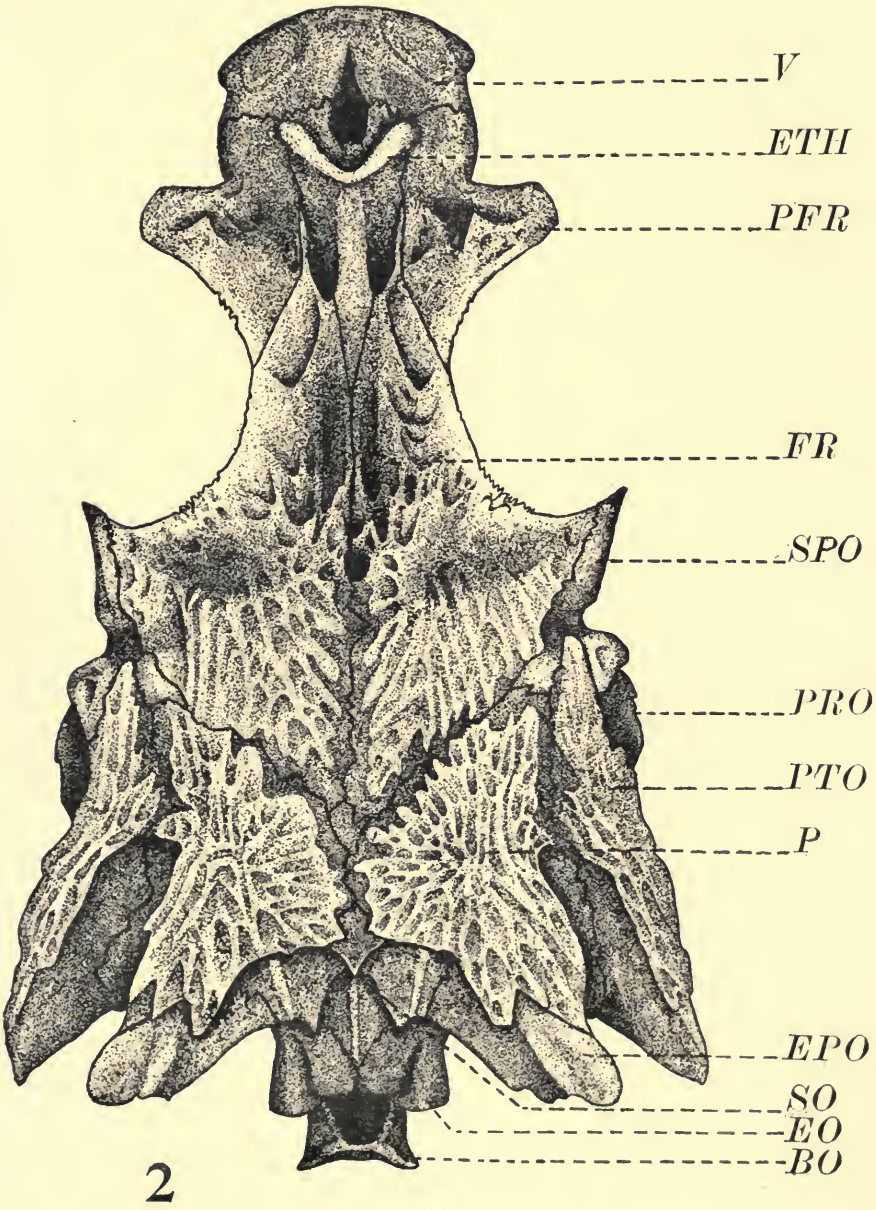
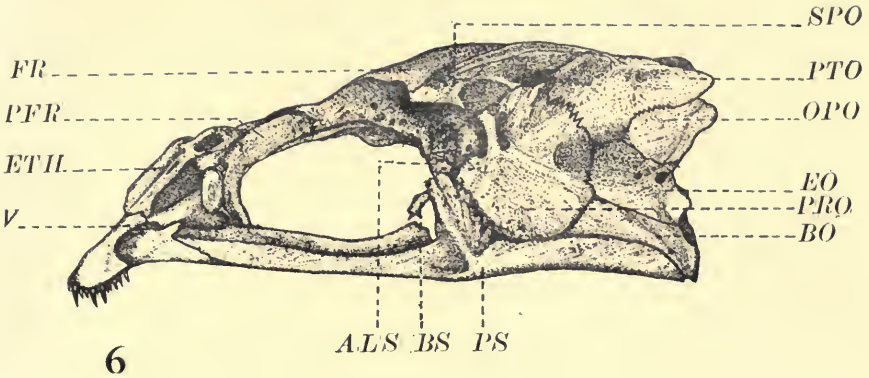


PLATE II

PLATE III

EXPLANATION OF PLATE

Fig. 3. Prepoercular of *Scorpianichthys marmoratus.* Two-thirds natural size.
Fig. 4. Preopercular of *Ophidon elongatus.* Two-thirdds natural size.
Fig. 5. Lateral view of skull of *Scorpionichthys marmoratus.* Two-thirds natural size.
Fig. 6. Lattral view of skull of *Ophidon elongatus.* Two-thirds natural size.



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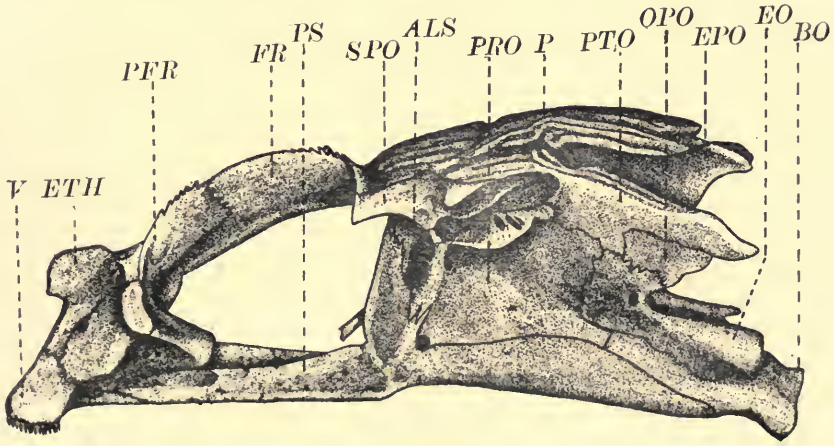

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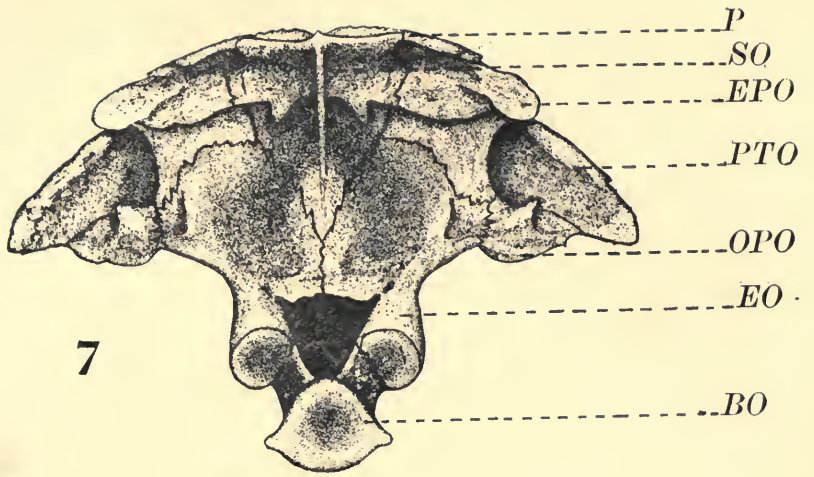
PLATE III

PLATE IV

EXPLANATION OF PLATE

Fig. 7. Posterior view of skull of *Scorpionichthys marmoratus*. Three-fourths natural size.
Fig. 8. Posterior view of skull of *Ophidon elongatus*. Three-fourths natural size.
Fig. 9. Premaxillary of *Ophidon elongatus*. Three-fourths natural size.
Fig. 10. Premaxillary of *Scorpionichthys marmoratus*. Three-fourths natural size.



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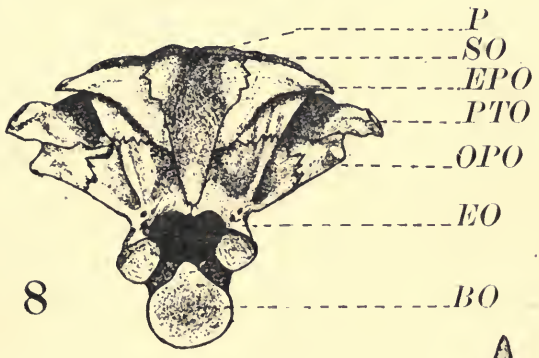

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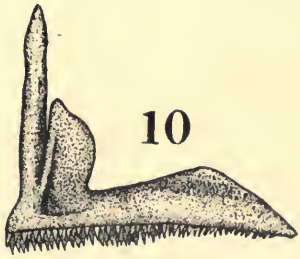

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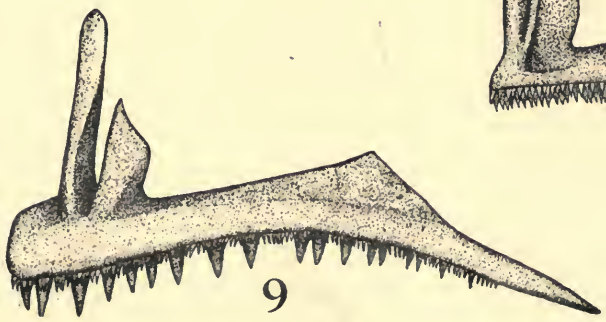

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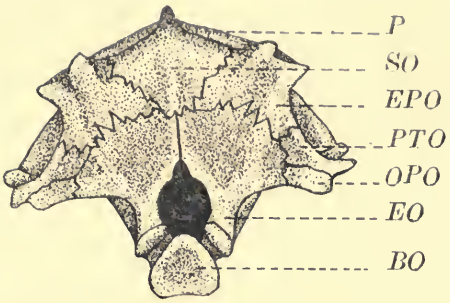
PLATE IV

PLATE V

EXPLANATION OF PLATE

HEXAGRAMMOS DECAGRAMMUS

Fig. 11. Posterior view of skull. One and one-half times natural size.
Fig. 12. Lateral view of skull. One and one-half times natural size.
Fig. 13. Dorsal view of skull. One and one-half times natural size.



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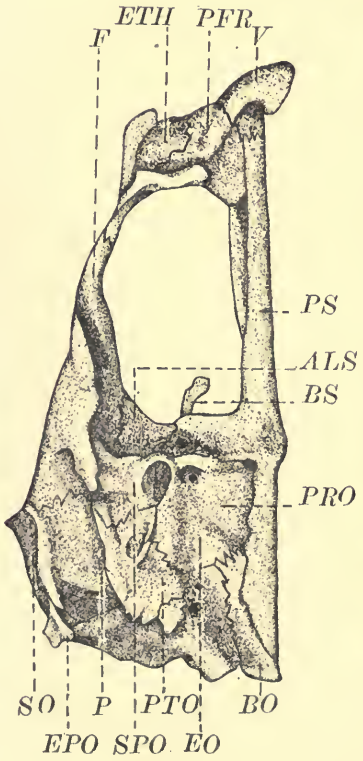

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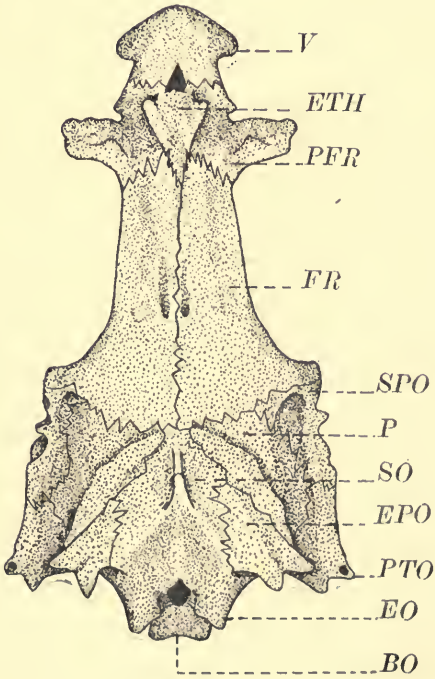

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PLATE V

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